DOCUMENT RESUME

ED 247 719 EC 170 074

AUTHOR Kusche, Carol A.
TITLE Linguistic Processing, Encoding Capacities, and Reading Achievement in Deaf Children and Adolescents.
PUB DATE Jun 84
NOTE 33p.; Contained in: International Symposium on Cognition, Education, and Deafness (Washington, DC, June 5-8, 1984). Working Papers. Volumes I and II. David S. Martin, Ed.
PUB TYPE Speeches/Conference Papers (150) -- Reports - Research/Technical (143)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Deafness; Elementary Secondary Education; *Encoding (Psychology); *Linguistics; Memory; *Reading Achievement; *Reading Instruction; Recall (Psychology); *Short Term Memory

ABSTRACT

The purpose of the present paper is to provide order to the existing data to allow for theoretical explanations concerning the specific factors involved in linguistic processing, memory development, and reading achievement in deaf children and adolescents. Language processing skills and short-term memory encoding are reviewed as essential components in good reading comprehension. Research concerning the short-term encoding capacities of the deaf is presented, followed by the relationship between short-term memory and reading ability in deaf children. The essential factors necessary for effective encoding are then examined and the hypothetical implications regarding hemispheric lateralization raised. The remainder of the paper focuses on implications for education and research, including the use of a theoretical model for reading instruction that includes instruction in encoding, memorization and recall, and problem-solving and logical thought. (Author/CL)

****
Reproductions supplied by EDRS are the best that can be made *
from the original document. *
****

ED247719

LINGUISTIC PROCESSING, ENCODING CAPACITIES, AND READING ACHIEVEMENT IN DEAF CHILDREN AND ADOLESCENTS

Carol A. Kuschè
University of Washington

Abstract

It is well known that deaf children and adults generally show very poor reading achievement, which is believed to be due to early language deprivation and resulting deficiencies in linguistic development. The purpose of the present paper is to provide order to the existing data to allow for theoretical explanations concerning the specific factors involved in linguistic processing, memory development, and reading achievement in deaf children and adolescents. Language processing skills and short-term memory encoding will first be reviewed as essential components in good reading comprehension. Research concerning the short-term encoding capacities of the deaf will then be presented, followed by the relationship between short-term memory and reading ability in deaf children. The essential factors necessary for effective encoding will then be examined and the hypothetical implications regarding hemispheric lateralization will be raised. The remainder of the paper focuses on implications for education and research.

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☑ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Carol A Kuschè

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

EC170074

Introduction

It is well known that deaf children and adults typically show very poor reading achievement (Conrad, 1977, 1979; Furth, 1966; Trybus & Karchmer, 1977) and that improvement over time appears to be minimal (Fiedler, 1969; Hammermeister, 1971; Wrightstone, Aronow, & Muskowitz, 1963). Early language deprivation and resulting deficits in linguistic development are generally believed to be responsible for poor reading achievement, since intelligence is clearly not the issue (Meadow, 1980). This distinction is an important one, and it should be underscored that functions such as language and memory are not equivalent to cognition. In other words, deficiencies in language or memory cannot be equated as deficits in thinking. As Tomlinson-Keasey and Kelly (1978) noted, "deafness means that the information-processing system of the child takes a decidedly different developmental turn" (p. 457), but the specific factors involved in this "different developmental turn" are still far from understood.

The purpose of the present paper is to provide order to the existing data to allow for theoretical explanations concerning the specific factors involved in linguistic processing, memory development, and reading achievement in deaf children and adolescents. Language-processing skills and short-term memory encoding will first be reviewed as essential components in good reading comprehension. Research concerning the short-term encoding capacities of the deaf will then be presented, followed by the relationship between short-term memory and reading ability in deaf children. The essential factors necessary for effective encoding will then be examined and the hypothetical implications regarding hemispheric lateralization will be raised. The remainder of the paper will then focus on implications for education and research.

Reading as a Language-Based Skill

For hearing children, listening skills are acquired "naturally" and with relative ease, while reading must be taught. The majority of deaf children, however, learn both skills slowly, and usually as a result of many years of deliberate instruction (the exception to this point is the subgroup of deaf children with deaf signing parents who receive continual exposure to language from birth and who generally acquire linguistic understanding much earlier than the average deaf child). This continual linguistic stimulation facilitates the child's ability to comprehend language. When the child later learns to read, s/he acquires the capacity to do visually what s/he can already do auditorally or cherologically (in signs). "The language signals are all the same. The difference lies in the medium through which the physical stimuli make contact with the nervous system" (Fries, 1962, xv). For hearing individuals, listening involves sound waves received by the ear, while reading involves light waves received by the eye. It appears that the "acquisition of both the spoken and written language requires development of 'high-speed recognition responses' to stimuli which 'sink below the threshold of attention' (Fries, 1962, xvi) when the responses have become habitual" (Mattingly, 1972).

Habitual responses develop when skills are highly (or over) learned, often because of years of practice. Once an ability becomes automated, conscious attention and mental energy are only minimally required (Norman, 1976). Automaticity thus involves unconscious processing, which is far more efficient than conscious processing. Examples of skills which can become automated include walking, driving, typing, eating, talking, and reading. When we consciously attend to or concentrate on any of these skills (which we all did while learning them), we usually note that much more effort is involved and that the task seems much more difficult.

It has been suggested that reading is a language-based skill which ultimately depends on linguistic awareness (Mattingly, 1972). Wolff (1973) noted that language is normally first acquired through an aural-oral mode, which he referred to as a "primary medium." Once the basic patterns of a language are well-acquired (i.e., once they attain an automated status), children can learn to recognize them in a secondary medium of written language. According to Wolff, economic encoding in memory allows the primary medium to assist learning in the secondary medium. Because most stimulation is redundant, the human nervous system tends to seize on any pattern and use this redundancy as a means for storing information economically in long-term memory. Thus, the hearing child discovers the correspondence between letters and speech sounds, and patterns of letters come to be seen as more than arbitrary sequences. Similarly, the knowledge of spoken language helps the child to process written words in a logical order. In other words, the primary medium must be learned "from scratch," but once the patterns of the system become automatic, they can be transferred relatively easily into secondary media such as reading and writing, provided that the systems are reasonably similar.

For the deaf child, early language deprivation and limited linguistic experience with the environment not only curtail the child's knowledge of the world, but also severely restricts the primary linguistic knowledge available in long-term memory store. In other words, deaf children deprived of early language, who are generally weak in their automatic or unconscious understanding of the patterns, rules, and strategies for linguistic performance, lack the repertoire necessary for easy transference to a new language-based skill.

Short-Term Memory Encoding and Reading Ability

As noted before, listening for hearing individuals involves sound waves received by the ears, while reading involves light waves received by the eyes.

There appears to be a need for "translation" from the visual mode into an alternate mode in order to make use of the information which is in long-term memory store. In other words, visual signals need to be recoded into other types of signals, and for hearing individuals this coding appears to be generally achieved through the use of phonemic encoding.

Hearing individuals tend to subvocalize during silent reading, although it is usually not noticeable to themselves or to other people (Locke, 1971). It has been suggested that speech recoding "facilitates the temporary storage of words necessary for sentence comprehension" and that it occurs after lexical access (Kleiman, 1975, 323). Slowiaczek and Clifton (1980) suggested that subvocalization leads to a more durable memory representation needed for concept integration and that it reorganizes visual input into a prosodic structure which allows access to information needed for sentence processing and comprehension. That is, subvocalization allows information to be retained in short-term working memory and the prosodic structure provides the reader with additional cues, such as intonation and rhythm. To transfer information to another mode of short-term memory would seem to be a logical necessity for sentence comprehension, since visual short-term memory has a rapid decay rate (Sperling, 1960). (In fact, if you were presently relying only on visual short-term memory, you would have forgotten the beginning of this sentence by the time you got to here!) The transformation of visual images into prosodic structure provides the "translation" or recoding necessary for hearing individuals to take advantage of the linguistic information available in long-term memory store.

Studies with hearing children have emphasized the importance of verbal coding efficiency in determining differences, both individual and developmental, in reading comprehension. Good comprehenders have been found to be more proficient at encoding semantic and phonological information (Guttentag & Haith, 1978; Mark,

Shankweiler, Liberman, & Fowler, 1977; McFarland & Rhodes, 1978) and to be faster word decoders (Golinkoff & Rosinski, 1976; Perfetti, Finger, & Hogaboam, 1978). Savin (1972) reported that hearing children who failed to read even simple prose by the end of first grade were all unable to analyze syllables into phonemes.

Recently, Hess and Radtke (1981) found that for hearing children, two independent factors accounted for significant differences in reading comprehension at both the individual and developmental levels: processing speed (including retrieval from semantic memory and scanning speed of working memory contents) and general memory ability. The nature of the memory factor was unclear, but the authors suggested that "superior short-term memory skills could influence comprehension by increasing the amount of text information that can be maintained in working memory for integration purposes (Kintsch & Van Dijk, 1978) or by allowing exact word information to be retained for a longer time while semantic codes are being established (Perfetti & Lesgold, 1977)" (Hess & Radtke, 1981, p. 487).

At least two important factors are related, then, to reading comprehension skill: (1) processing speed (which involves long-term memory, past experience, linguistic understanding, and retrieval ability), and (2) short-term memory (which for hearing individuals seems to involve phonetic encoding). Presumably, information which is not encoded cannot be processed, but the reverse is not necessarily the case. We have already established that for most deaf children, we would expect to see large deficiencies in processing speed. However, are the deaf child's reading abilities also affected by deficits in short-term memory skills? Unfortunately, research to date indicates that the answer is affirmative.

Short-Term Encoding Capacities of the Deaf

In their classic study of memory span for digits, Pintner and Paterson (1917) found that "the average deaf child at any age never equals the average ability of

seven-year-old hearing children" (p. 82) and concluded that "the startling backwardness of the deaf child in visual memory is in large part due to his lack of auditory experience" (p. 85). Subsequent research involving different memory span tasks similarly showed superior recall ability for hearing children and adolescents (Blair, 1957; Conrad & Rush, 1965; Goetzinger & Huber, 1964; Hermelin & O'Connor, 1975; Koh, Vernon, & Bailey, 1971; Withrow, 1968). In studies designed to ascertain differences in encoding strategies, O'Connor and Hermelin (1973) found that deaf children were eight times as likely to report spatial order as temporal order, while the reverse was true for hearing children by a factor of four, and Kelly and Tomlinson-Keasey (1976) found that young hearing children appear to dual-code visual information better than deaf children. MacDougall (1979) further found that young deaf children relied almost exclusively on visual processing, while both visual and auditory cues were used by deaf adolescents. This developmental pattern was reversed for hearing subjects.

In comparing oral and manual deaf subjects, Wallace and Corballis (1973) found that both groups utilized primarily visual encoding when four-letter sequences were presented. When five-letter sequences were given, however, the oral deaf subjects used both visual and acoustic encoding. The manual deaf group did not rely on acoustic encoding, but utilized other types of encoding which were not specified. Evidence that orally-trained deaf children (Locke, 1978) and deaf adolescents with unreported mode of communication (Chen, 1976) do not effectively mediate connected prose with speech was provided by two similar studies in which deaf subjects detected significantly more silent letters while reading than did hearing subjects.

In comparing native-signing ASL deaf college students to hearing young adults, Hanson (1982) found that deaf subjects recalled fewer words when ordered recall of words was required, but not when the task involved free recall. When

probed for ordered recall, the deaf subjects tended to use a speech-based code, and the more the speech-based code was utilized, the more accurate the recall. This finding was interesting because research has suggested that order and item information are stored independently in short-term memory (Bjork & Healy, 1974). A phonetically-based memory code appears to especially facilitate the retention of ordered information.

Research has also addressed the effect of sign language abilities on memory encoding. Odom, Blanton, and McIntyre (1970) found that deaf children were more likely to remember words when there were sign language equivalents for these words than when there were not. Moulton and Beasley (1975) reported that signing deaf adolescents were able to encode verbal material on both a sign and a semantic basis. Other studies have also shown that cherology (sign language) is an effective encoding system for deaf children (Frumkin & Anisfeld, 1977), deaf adolescents (Conlin & Paivio, 1975), and deaf college students (Bellugi, Klima, & Siple, 1975; Shand, 1982). Hirsh-Pasek and Treiman (1979) reported that deaf adults tended to recode into fingerspelling while reading. In addition, some deaf adults systematically recoded into signs.

Locke and Locke (1971) observed that a small proportion of deaf adolescents utilized either phonetic or phonetic and dactylic (fingerspelling) rehearsal strategies during a recall of letters task. Liben and Drury (1977) reported frequent gestural and/or oral labeling by deaf children, but similarly found little evidence for cumulative rehearsal. With hearing children, the spontaneous use of verbal rehearsal as a mnemonic strategy, which involves a complex coordination and integration of skills, clearly increases with age and is important for long-term memory storage (Flavell, 1977). The development of rehearsal strategies in the deaf population (verbal and manual) is an area badly in need of research.

Recently, Hung, Tzeng, and Warren (1981) conducted three experiments to study the reading ability of deaf adolescents who were familiar with Total Communication. The researchers concluded that "deaf subjects are capable of linguistic coding strategy, but they do not apply it to process printed English sentences (p. 583) . . . deaf children do not have the phonological repertoire upon which English orthography is based" (p. 606). They also concluded that deaf children do not develop automaticity for such skills as letter decoding and word recognition.

In summary, the studies involving encoding abilities of the deaf are somewhat difficult to compare, partly because different tasks are involved and partly because different populations of deaf subjects have been utilized (e.g., deaf children of deaf parents, orally-trained, deaf with recent sign language acquisition, etc.), and the subjects' primary mode of communication is often not reported (a crucial oversight to be avoided by future researchers!). However, certain conclusions seem to emerge from the large body of data:

(1) Deaf subjects (children and adults) tend to do very poorly on memory span tests or on tasks in which the order of information is important.

(2) Deaf subjects do not generally utilize phonetic encoding strategies.

(3) Encoding strategies differ between deaf and hearing subjects at all developmental levels studied.

(4) There appears to be much variability among deaf subjects in types of encoding strategies used.

The Visual Aural Digit Span (VADS) Test

Recently, the present author assessed the memory span skills of 59 deaf school-age children (all receiving instruction in Total Communication, speech plus Manual English) on the Visual Aural Digit Span (VADS) Test (Koppitz, 1977). In each of four subtests, the child was presented progressively longer digit series

as follows: (1) The digits were presented once in TC and the child recalled in TC, sign, or orally as the child desired (similar to Aural-Oral). (2) The digits were printed on cards which the child studied for 10 secs. Recall was in TC, sign, oral (similar to Visual-Oral). (3) The digits were presented once in TC and the child was asked to write down the recalled response (similar to Aural-Written). The digits were presented on cards for 10 secs. and the child was asked to write down the recalled response (similar to Visual-Written).

The children were grouped into three developmental levels based on mean ages (7-3, N=19; 9-7, N=20; 12-1, N=20). Each subtest was scored according to the highest number of digits correctly recalled (highest possible score on any one subtest = 7) and published hearing norms were used for purposes of comparison. As can be seen in Figure 1, the deaf subjects scored lower on all subtests than the hearing subjects, although the same developmental patterns were obtained. The visual subtest scores were far superior and it was observed that on these subtests, the deaf subjects generally used dactylic/verbal (TC) rehearsal to encode the digits.

Subtest scores were then collapsed, and as can be seen in Figure 2, the total score indicated little overall memory improvement after the age of 9½ (strikingly reminiscent of the asymptote reported for reading comprehension scores).

Memory quotients for each child were then calculated by dividing age equivalent scores for the total test by the child's chronological age. As can be seen in Figure 3, the mean MQ score was 91 at age 7-3, 81 at age 9-7, and 65 at age 12-1. However, it should be emphasized that memory span did not decrease with age; it simply did not show the normal developmental improvement found with hearing children. As a result, the 12-year-old deaf children evidenced "retarded" memory development.

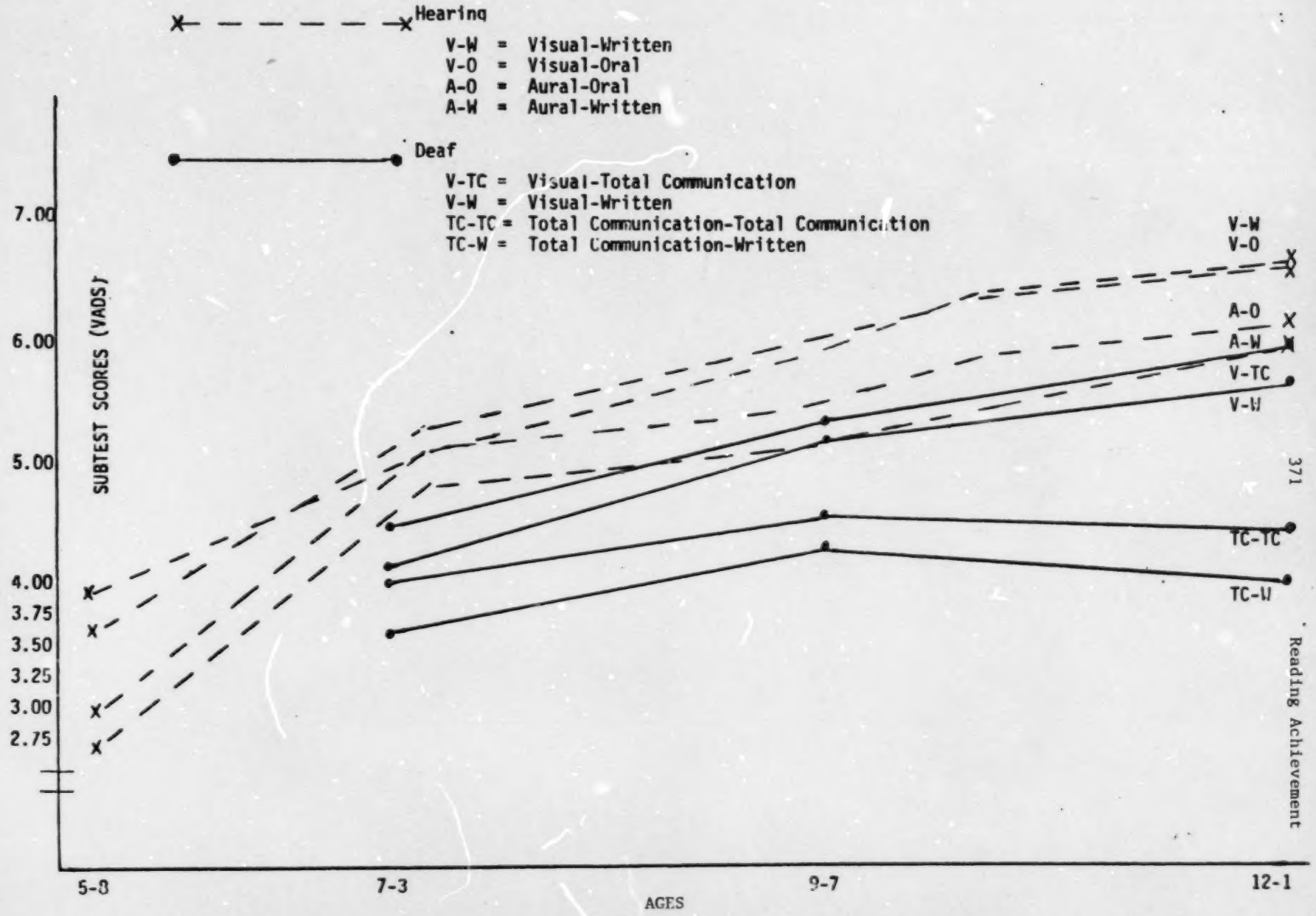

Figure 1. Mean Subtest Scores on the VADS for Deaf and Hearing Children

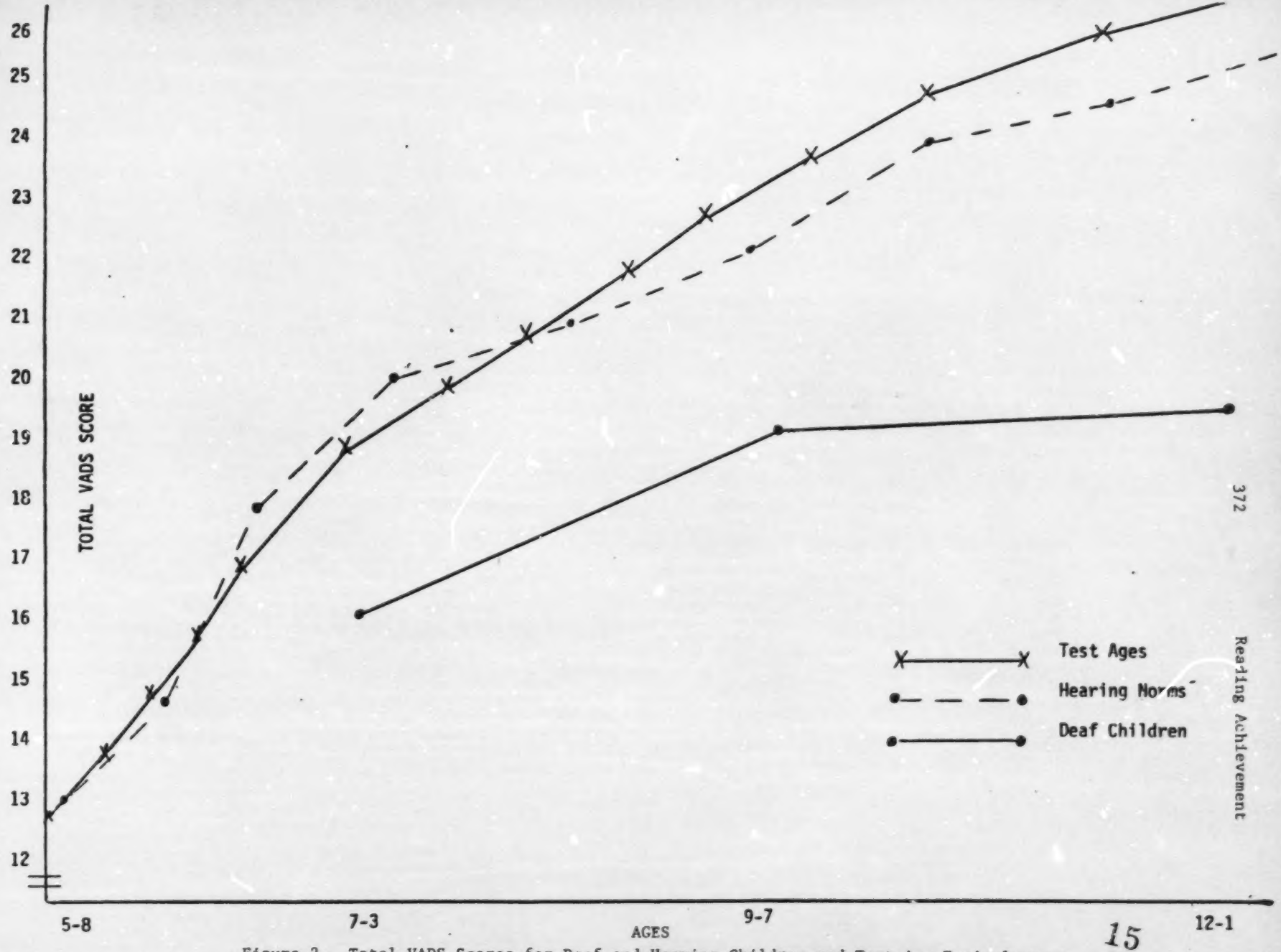

Figure 2. Total VADS Scores for Deaf and Hearing Children and Test Age Equivalents

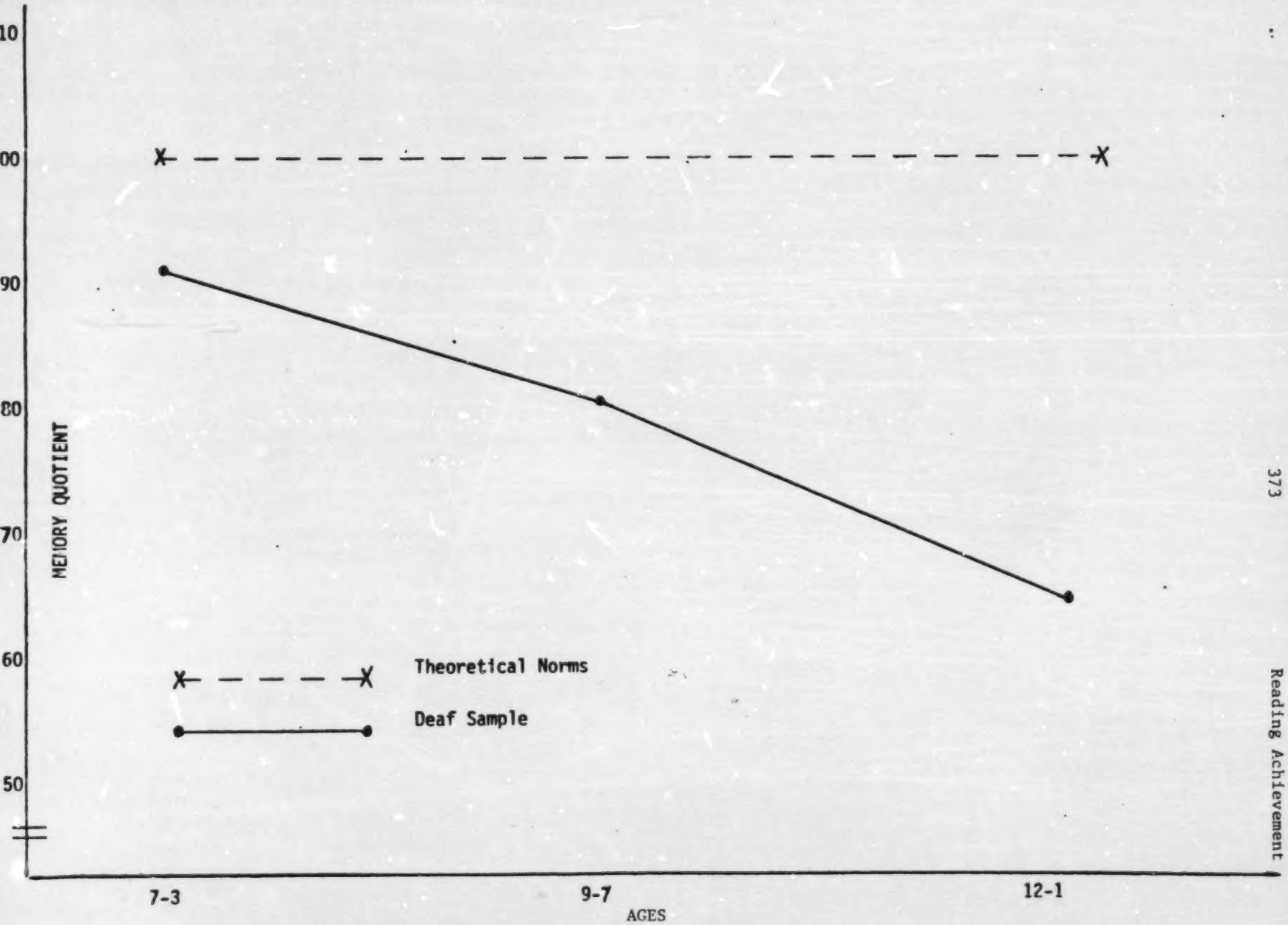

Figure 3. Memory quotient scores for deaf children compared to theoretical norms

It should be noted that these data are very rough (and are considered to be pilot data at this point). Hearing loss, age of onset, and so forth were not controlled in this analysis, and more refined analyses are currently underway. These data will also be correlated with other measures obtained on these same children (e.g., reading comprehension, speech intelligibility, nonverbal IQ), and retesting is planned for purposes of longitudinal validation. These data are included only to show that in a random sampling of school-age deaf children, overall memory ability is severely compromised.

One further observation is of interest here. The present author was struck by the fact that when many of the children were presented with four or more digits in TC (1 sec. each digit), they became flustered (e.g., shaking their hand, signing "hard"). This finding has important implications for memory and TC comprehension skills as well as for reading. Perhaps we often assume that deaf children (or adults) understand us because we are signing to them. If memory span and encoding skills are as crucial for TC comprehension as they are for reading, one is left with the speculation that deaf children are missing much of the communication that hearing children listen to "naturally" or automatically. The implications for education are crucial, and research in this area is badly needed.

Short-Term Memory and Reading Ability in Deaf Children

In his study comparing memory abilities of deaf and hearing school-age children (primary mode of communication not given), Blair (1957) found that all of the memory-span tasks were significantly correlated with the reading achievement of the deaf subjects (r = .30 to .70). Hartung 1970) similarly found significant correlations between reading scores and recall tasks for both school-age hearing and orally-trained deaf children (r = .55 to .71). Significant correlations between reading scores and memory recall in orally-trained deaf high school students

were also obtained in a tachistoscopic study (Carey & Blake, 1974). Correlations between IQ scores and recall, however, were found to be insignificant, again emphasizing the earlier point that language and cognition are not equivalent.

The classic work comparing memory abilities and reading achievement was Conrad's (1979) study of 468 orally-trained English deaf school-leavers. Using an analysis of covariance, Conrad determined that the effect of internal speech (i.e., phonemic encoding) on reading achievement was larger than the effect of hearing loss. He concluded that "degree of deafness in itself is not a major factor in reading comprehension. What seems to be much more important, apart from intelligence, is whether or not the child has acquired the use of internal speech (p. 157) . . . In general, without internal speech, children are likely to be below average readers regardless of their hearing loss or intelligence" (p. 160).

Phonemic Encoding: Is It Essential for Good Reading Achievement?

Phonemic encoding appears to be of great importance for hearing readers. But must a child or adult utilize "internal speech" or phonemic encoding to be a good reader, as suggested by Conrad? Research currently available suggests that the answer is "No"; it appears that the kinesthetic or proprioceptive recoding associated with phonemic encoding is most important, and this point is of crucial significance for educators and researchers in the field of deafness. Hintzman (1967), for example, found that with hearing adults, both voicing and place of articulation significantly influenced confusion errors in short-term memory for visually-presented nonsense syllables. These results are consistent with a hypothesis for mediation by kinesthetic feedback, but inconsistent with a hypothesis for mediation by auditory images only. The finding that profoundly, congenitally deaf subjects who are proficient signers can recode orthographic stimuli into a sign-based code is also consistent with a kinesthetic feedback hypothesis rather

than a hypothesis for phonological recoding. As Shand (1982) noted, "analyses of human memory which place a strong emphasis on the preference for phonological coding in short-term memory processes may reflect the audiocentricity of the experimenters rather than anything inherent in such processes" (p. 11).

It may be that the kinesthetic feedback produced by either sign or phonetic encoding allows for memory traces of longer lasting duration than is available with visual memory. It may also be the case that the recoding process is most efficient when it parallels the reader's prominent mode of communication (e.g., signs for signers, phonemes for hearing speakers), which is consistent with the theory of economic encoding. Thus, Conrad's (1979) finding of a high correlation between good reading skills and well developed "internalized speech" (i.e., phonetic encoding capacities) in a group of orally trained deaf students is not surprising. It is important to remember, however, that this method does not appear to be the only effective form of recoding available.

Hardyck and Petrinovich (1970) proposed the following theory based on research on subvocalization in hearing readers:

> [T]he process of learning to read can be conceptualized as a motor skill which develops through several stages of integration into a centrally programmed neural analogue. The preliminary stages of learning to read are characterized by the production of (a) sounds that are the speech responses to visual stimulus objects, and (b) the proprioceptive and auditory consequences of producing these sounds which, in turn, can serve as a stimulus support for the responses. This auditory-proprioceptive stimulus complex is considered to be the most stable mediator in the associative learning of the auditory set of symbols the organism encounters when learning to read: that is, to associate a set of visual symbols to a vocal response. As skill increases the gross motor components are eliminated gradually and are replaced by unidentified neural analogues.
>
> Once such neural analogues are developed, the auditory-proprioceptive stimulus complex can be eliminated since it is now a redundant stimulus; the visual stimulus alone is sufficient. Even though eliminated, the auditory-proprioceptive stimulus complex may be reactivated when a high degree of redundancy of stimulus input is needed (p. 651).

Of related interest to educators of the deaf is the finding that when words were presented auditorially to orally-trained, profoundly deaf children, they perceived the syllabic patterns to be very different from the normal auditory perception of hearing adults. However, the deaf children's perception of the syllabic patterns was very similar to their vibrotactile perception of the words and to the vibrotactile perception experienced by normal hearing adults (Zeiser & Erber, 1977). Since the perception of syllables for these children is quite deviant from normal auditory perception one would assume that phonemic encoding would be difficult at best, but more likely, impossible. Since sign language was not utilized and visual encoding is inadequate, one would predict that this oral group of subjects most likely evidences very poor reading skills.

Finally, in his study, Conrad (1979) noted that even when two subgroups of deaf adolescents were matched to hearing controls on use of "internal speech," the deaf subjects nevertheless showed very poor reading achievement as compared to the expected age norms for hearing students, regardless of hearing loss. This finding is again an indication that phonetic encoding may facilitate reading, but it is not sufficient in and of itself. As was noted earlier, there are at least two crucial factors associated with good reading, and good encoding skills alone are not enough. Deficits in linguistic knowledge and automaticity for language are also likely to interfere with reading achievement. Another factor may also be related here and may prove to be of crucial importance: Hemispheric specialization and lateralization for verbal memory and language-related functions.

Encoding Processes and Hemispheric Lateralization

Research with commissurectomized and aphasic hearing patients indicates that the right hemisphere of the brain is limited in its ability to remember sequential information, although it is likely to understand the meaning of individual words

(Gordon, 1983; Zaidel, 1976, 1977). It appears that the left hemisphere generally has superior capacities for auditory memory-span tasks. Furthermore, several studies of hearing children with reading problems and other auditory-linguistic difficulties have indicated right hemisphere superiority for linguistic abilities in these children (Marcel, Katz, & Smith, 1974; Sommers & Taylor, 1972; Witelson & Rabinovitch, 1972). Right hemisphere specialization for language has also been observed in rare cases of severe language deprivation in hearing children and the possibility has been raised "that prolonged absence of language training can produce a functional atrophy of speech centers in the left hemisphere" (Gordon, 1983, 48). If this theory is correct, the implications for language deprivation during the deaf child's early childhood and subsequent hemispheric lateralization/specialization and encoding abilities would be of immense importance. Again, it is important to remember that this point does not imply that language and cognition are equivalent; they clearly are not.

Studies on deafness and hemispheric lateralization are unclear at present. Research with deaf adults who have developed different types of sign aphasias as a result of stroke provided good evidence for left-hemispheric linguistic processing and right hemispheric spatial-visual processing (Bellugi, 1983), as is found with the majority of hearing adults. All of these subjects, however, had had deaf parents and most likely received linguistic input from birth, since they came from signing families. Kelly and Tomlinson-Keasey (1977) found that deaf school-aged children generally showed no lateral specialization, but did process high image word stimuli more effectively with the right hemisphere. Primary mode of communication was not given for this group of subjects. Phippard (1977) found that orally trained deaf adolescents processed both verbal and visual material more efficiently with the right hemisphere, while deaf adolescents trained in Total Communication showed no evidence for lateral specialization. While the deaf

groups differed from each other, they also both differed from hearing adolescent controls who showed the expected left hemispheric superiority for nonverbal material. Differences in hemispheric specialization and lateralization in the deaf may have clear implications for reading ability and is an area badly in need of further research.

The hypotheses that early auditory deprivation or severe hearing loss per se lead to differences in hemispheric organization are clearly in error, since signing deaf subjects with deaf parents show the expected hemispheric lateralization. It may well be, however, that the lack of early language stimulation and training results in differences in lateralization or specialization of the brain. Further research is needed, but if this hypothesis is supported, the critical importance of early language training and intervention is clear. In addition, research needs to address the question of sensitive periods. Can hemispheric lateralization be facilitated at any point in development? If so, how is this facilitation best accomplished? If not, how does one best teach deaf students such language-related tasks as reading, given the lateralization (or lack of it) already developed? Do differences in hemispheric organization affect short-term encoding capacities or long-term memory storage? These questions are clearly of crucial importance for the education of the deaf.

Implications and Suggestions for Education and Research

A summary of the currently available research indicates that deaf children demonstrate deficiencies in both linguistic processing and memory encoding. Since these factors appear to be very important for reading, it is not surprising that deaf individuals generally evidence very poor reading achievement. It is also possible that the development of hemispheric lateralization/specialization for language and memory skills is typically being comprised. Given these findings, it

would appear that intervention and remediation are of crucial importance and should be instituted at as early an age as possible. It is suggested that reading programs designed for hearing children are not adequate for deaf children and that reading instruction programs should be developed specifically for the hearing-impaired population. Furthermore, careful research should be undertaken to assess the effectiveness of these programs. The specific components of the programs should be tested, and only the successful aspects should be retained.

A reading program designed specifically for young deaf children was recently conducted with Swedish deaf preschool children (Söderbergh, 1981). The program appeared to be quite successful, but unfortunately neither adequate control groups nor systematic measurements were used in the research. Nevertheless, the results are encouraging and seem worthy of further investigation.

In this project, forty deaf and hard-of-hearing Swedish children, ages 3-6, were taught basic reading skills through the use of functional and play activities, matching words to objects, rehearsal and underscoring of key words, and matching alphabet cards to corresponding letter cards (word analysis). At the end of the 9-month project, the children were able to read and write basic prose, they were considered to be more inquisitive and eager to learn, their sign language was considerably improved, they produced more and better articulated speech, and they could solve everyday practical problems by using language. With reference to encoding skills, it was observed that "when reading difficult words, the deaf children sometimes stopped, fingerspelled the words, and in this way identified them. Afterward, the children could make the right signs for the words in sign language. This may mean that the deaf children break the code visually-kinesthetically instead of auditorally, or orally" (p. 382).

The present author offers the following suggestions for a reading program, based on the current available research. This theoretical model is entitled PRIDE

(Providing Reading Improvement in Deaf Education), and includes the following components (whose validity and merit would need to be tested through well-designed research):

(1) Instruction in phonetic, dactylic, and cherologic encoding.

Deaf children should be taught to "sound out" new words as well as possible, with emphasis on number of syllables, stressed vs. unstressed syllables, voiced vs. unvoiced phonemes, and sites of articulation (front, middle, back, sides). The word "girls," for example, has one syllable (and stressing is therefore not an issue). Motor movements, such as tapping the hand on the table for each syllable (with extra emphasis for stressed syllables) may help facilitate the learning of syllabification. To continue with the example of "girls," there are four phonemes, all of which are voiced. The sites of articulation are from back of the tongue to back of palate ("g"), which glides into sides of tongue up to sides of palate ("er"), tip of tongue to front of palate ("l"), and teeth together ("z"). While this procedure may seem to be a complex undertaking, the present author found it to be very effective during speech lessons, even with profoundly deaf children. Once the child understood the system, it was often only necessary to explain the site and mode of articulation once and then cue with hand signals and signs during practice. It should also be noted that number of syllables and number of articulation sites (phonemes) can be very different (as in "girls") and provide different information, which may at first be confusing for deaf children. However, deaf children need to develop a better awareness (metacognition) regarding vocabulary and language, because they are not able to gain this information through aural feedback as hearing children do.

Children being trained in TC should also be taught to practice new words by fingerspelling them with emphasis on grouping letters according to syllables. After fingerspelling a new word several times, the word should then be signed so that the sign and spelling become associated with the printed visual image. Following the TC philosophy, the children should also voice the letters and words while signing.

The words can be printed on cards for use in instruction, but flash cards should not be used, as is often the custom. Flash cards encourage the development of visual encoding, which will not be beneficial for later reading that involves more than one word at a time.

(2) Memorization and recall training.

Deaf children should be taught to use rehearsal strategies (verbal and manual) to improve their encoding abilities, and hopefully, to improve their memory spans. Short stories should also be

learned from memory and repeated so that the child develops automaticity for visual words, speech, and signs (and linguistic structure). Even after a story has been memorized, the child should look at the printed script as s/he reads in TC (or orally) so that the visual print, speech, and signs become associated and automated. Instruction in phonemic games, such as Pig Latin and rhyming, is also recommended. Singing songs is another good way to improve memory abilities.

(3) Stories should be written which are of particular relevance for deaf children and which relate to their life experiences.

With preschool children, for example, a story could be written about making cookies. The children could first act out the story by making cookies and could label the actual nouns and actions with word cards as they went along. After "participating" in the story (on a sensorimotor level), they could learn to read it (on a concrete, symbolic level). With older children, stories could include themes of personal importance, such as things that happen at home, feelings about being mainstreamed, getting into trouble for pushing, staying overnight at a friend's house, and so forth. Emotion concepts should also be incorporated in the stories, because they are highly salient to deaf children, and they are also important for understanding characterization, reasons for actions, and so forth. Three-dimensional objects and manipulative illustrations can also be used.

(4) Attribution training.

For many deaf children, reading instruction has become a failure experience, and so it is approached with feelings of dread and avoidance. Motivation can be improved by helping the child to frame reading as an enjoyable experience that can lead to personal success. One cannot force a child to enjoy reading a story, but one can reflect feelings of frustration and fear of failure, which often helps the child to understand his/her emotions and how they are related to his/her behaviors (e.g., "You're frustrated and upset about reading that story because it's hard for you. Maybe you wish you didn't have to read that story at all."). When children feel understood, they are much more likely to stick with a hard task. The educator should always remember how difficult reading is for most deaf children, and praise for successes should be liberally given.

(5) Training in problem-solving and logical thought.

Instruction in following logical steps and problem-solving sequences should help deaf children improve memory and metacognitions for ordered information. It would also help these children to develop a structure or framework for analytic thinking.

(6) Training in metacognitions regarding grammar and linguistic structure.

Deaf children need to be taught the linguistic patterns that hearing children develop "automatically" because of years of

practice. Training in language patterns should help the deaf child to develop automaticity for linguistic processing.

During the past several years, the author has assisted in the development and assessment of a social awareness--cognitive skills training curriculum, written and designed specifically for deaf school-age children (PATHS for Deaf Children; Greenberg, Kusche, Gustafson, Coady, Calderon, & Hyman, unpublished). This program utilizes many of the concepts listed above, although reading instruction was never an intended goal. At the conclusion of the first year of the curriculum, the authors were struck by the fact that in many ways, this program served as a reading improvement program. Even the very young experimental children learned to read such words as "embarrassed" and "frustrated" with relative ease (and knew what they meant!). The children were very enthusiastic about the stories provided, conversed about similar experiences they had had, learned to analyze characters and how the characters felt, analyzed situations in a logical order, etc. A more formal reading program designed specifically for deaf children could prove to be very effective. Give the current deficiencies in reading achievement, it would seem that the development and assessment of such a program should be of high priority in the field of education and deafness.

References

Bellugi, U. (1983). Brain organization: Clues from sign aphasia. Conference on the Development, Psycholinguistic, and Neurolinguistic Aspects of ASL, Seattle, Washington.

Bellugi, U., Klima, E. S., & Siple, P. (1975). Remembering in signs. Cognition, 3, 93-125.

Bjork, E. L., & Healy, A. F. (1974). Short-term order and item retention. Journal of Verbal Learning and Verbal Behavior, 13, 80-97.

Blair, F. X. (1957). A study of the visual memory of deaf and hearing children. American Annals of the Deaf, 102, 254-263.

Brasel, K. E., & Quigley, S. P. (1977). Influence of certain language and communication environments in early childhood on the development of language in deaf individuals. Journal of Speech and Hearing Research, 20, 95-107.

Carey, P., & Blake, J. (1974). Visual short-term memory in the hearing and the deaf. Canadian Journal of Psychology, 28, 1-14.

Chen, K. (1976). Acoustic image in visual detection for deaf and hearing college students. The Journal of General Psychology, 94, 243-246.

Conlin, D., & Paivio, A. (1975). The associative learning of the deaf: The effects of word imagery and signability. Memory and Cognition, 3, 335-340.

Conrad, R. (1977). The reading ability of deaf school-leavers. British Journal of Educational Psychology, 47, 138-148.

Conrad, R. (1979). The deaf schoolchild: Language and cognitive function. Harper & Row.

Conrad, R., & Rush, M. L. (1965). On the nature of short-term memory encoding by the deaf. Journal of Speech and Hearing Disorders, 30, 336-343.

Fiedler, M. F. (1969). Developmental studies of deaf children. ASHA Monographs, 5(13), Washington, D.C.: American Speech and Hearing Association.

Flavell, J. H. (1977). Cognitive development. Englewood Cliffs, N.J.: Prentice-Hall.

Fries, C. C. (1962). Linguistics and reading. New York: Holt, Rinehart, & Winston.

Frumkin, B., & Anisfeld, M. (1977). Semantic and surface codes in the memory of deaf children. Cognitive Psychology, 9, 475-493.

Furth, H. G. (1966). A comparison of reading test norms of deaf and hearing children. American Annals of the Deaf, 111, 461-462.

Goetzinger, C. P., & Huber, T. G. (1964). A study of immediate and delayed visual retention with deaf and hearing adolescents. American Annals of the Deaf, 109, 500-506.

Golinkoff, R., & Rosinski, R. (1976). Decoding, semantic processing, and reading comprehension skill. Child Development, 47, 252-258.

Gordon, W. P. (1983). Cerebral dominance: A guide for health care professionals. Stanford, CA: Cortext Research and Development.

Greenberg, M. T., Kusche, C. A., Gustafson, R., Coady, E. A., Calderon, R., & Hyman, J. (unpublished). The PATHS (Providing Alternative Thinking Strategies) Curriculum for Deaf Children.

Guttentag, R., & Haith, M. (1978). Automatic processing as a function of age and reading ability. Child Development, 49, 707-716.

Hammermeister, F. (1971). Reading achievement in deaf adults. American Annals of the Deaf, 116, 25-28.

Hanson, V. L. (1982). Short-term recall by deaf signers of American Sign Language: Implications of encoding strategy for order recall. Journal of Experimental Psychology: Learning, Memory, and Cognition, 8, 572-583.

Hardyck, C. D., & Petrinovich, L. F. (1970). Subvocal speech and comprehension level as a function of the difficulty level of reading material. Journal of Verbal Learning and Verbal Behavior, 9, 647-652.

Hartung, J. E. (1970). Visual perceptual skill, reading ability, and the young deaf child. Exceptional Children, 37, 603-608.

Hermelin, B., & O'Connor, N. (1975). The recall of digits by normal, deaf, and autistic children. British Journal of Psychology, 66, 203-209.

Hess, T. M., & Padtke, R. C. (1981). Processing and memory factors in children's reading comprehension skill. Child Development, 52, 479-488.

Hintzman, D. L. (1967). Articulatory coding in short-term memory. Journal of Verbal Learning and Verbal Behavior, 6, 312-316.

Hirsh-Pasek, K., & Treiman, R. A. (1979, September 15). Reading in the congenitally deaf. Paper presented at Boston University Conference on Language Development.

Hung, D. L., Tzeng, O. J. L., & Warren, D. H. (1981). A chronometric study of sentence processing in deaf children. Cognitive Psychology, 13, 583-610.

Kelly, R. R., & Tomlinson-Keasey, C. (1976). Information processing of visually presented picture and word stimuli by young hearing-impaired and normal-hearing children. Journal of Speech and Hearing Research, 19, 628-638.

Kelly, R. R., & Tomlinson-Keasey, C. (1977). Hemispheric laterality of deaf children for processing words and pictures visually presented to the hemifields. American Annals of the Deaf, 122, 525-533.

Kintsch, W., & Van Dijk, T. (1978). Toward a model of text comprehension and production. Psychological Review, 85, 363-394.

Kleiman, G. M. (1975). Speech recoding in reading. Journal of Verbal Learning and Verbal Behavior, 14, 323-339.

Koh, S. D., Vernon, M., & Bailey, W. (1971). Free-recall learning of word lists by prelingual deaf subjects. Journal of Verbal Learning and Verbal Behavior, 10, 542-547.

Koppitz, E. M. (1977). The Visual Aural Digit Span Test. New York: Grune & Stratton.

Liben, L. S., & Drury, A. M. (1977). Short-term memory in deaf and hearing children in relation to stimulus characteristics. Journal of Experimental Child Psychology, 24, 60-73.

Locke, J. L. (1971). Phonemic processing in silent reading. Perceptual and Motor Skills, 32, 905-906.

Locke, J. L. (1978). Phonemic effects in the silent reading of hearing and deaf children. Cognition, 6, 175-187.

Locke, J. L., & Locke, V. L. (1971). Deaf children's phonetic, visual, and dactylic coding in a grapheme recall task. Journal of Experimental Psychology, 89, 142-146.

MacDougall, J. C. (1979). The development of visual processing and short-term memory in deaf and hearing children. American Annals of the Deaf, 124, 16-22.

Marcel, T., Katz, L., & Smith, M. (1974). Laterality and reading proficiency. Neuropsychologia, 12, 131-140.

Mark, L., Shankweiler, D., Liberman, I., Fowler, C. (1977). Phonetic recoding and reading difficulty in beginning readers. Memory and Cognition, 5, 623-629.

Mattingly, I. G. (1972). Reading, the linguistic process, and linguistic awareness. In J. F. Kavanagh & I. G. Mattingly (Eds.), Language by ear and by eye: The relationship between speech and reading. Cambridge, MA: The MIT Press.

McFarland, C., & Rhodes, D. (1978). Memory for meaning in skilled and unskilled readers. Journal of Experimental Child Psychology, 25, 199-207.

Meadow, K. P. (1980). Deafness and child development. Berkeley: University of California Press.

Moulton, R., D., & Beasley, D. S. (1975). Verbal coding strategies used by hearing-impaired individuals. Journal of Speech and Hearing Research, 18, 559-570.

Norman, D. A. (1976). Memory and attention. New York: Wiley & Sons.

O'Connor, N., & Hermelin, B. M. (1973). The spatial or temporal organization of short-term memory. Quarterly Journal of Experimental Psychology, 25, 335-343.

Odom, P. B., & Blanton, R. L. (1970). Implicit and explicit grammatical factors and reading achievement in the deaf. Journal of Reading Behavior, 1, 47-55.

Odom, P. B., Blanton, R. L., & McIntyre, C. K. (1970). Coding medium and word recall by deaf and hearing subjects. Journal of Speech and Hearing Research, 13, 54-58.

Perfetti, C., Finger, E., & Hogaboam, T. (1978). Sources of vocalization latency differences between skilled and less skilled young readers. Journal of Educational Psychology, 70, 730-739.

Perfetti, C., & Lesgold, A. (1977). Discourse comprehension and sources of individual differences. In M. Just & P. Carpenter (Eds.), Cognitive processes in comprehension. Hillsdale, NJ: Erlbaum.

Phippard, D. (1977). Hemifield differences in visual perception in deaf and hearing subjects. Neuropsychologia, 115, 555-561.

Pintner, R., & Paterson, D. G. (1917). A comparison of deaf and hearing children in visual memory for digits. Journal of Experimental Psychology, 2, 76-88.

Savin, H. B. (1972). What the child knows about speech when he starts to learn to read. In J. F. Kavanagh & I. G. Mattingly (Eds.), Language by ear and by eye: The relationships between speech and reading. Cambridge, MA: The MIT Press.

Shand, M. A. (1982). Sign-based short-term coding of American Sign Language signs and printed English words by congenitally deaf signers. Cognitive Psychology, 14, 1-12.

Slowiaczek, M. L., & Clifton, Jr., C. (1980). Subvocalization and reading for meaning. Journal of Verbal Learning and Verbal Behavior, 19, 573-582.

Soderbergh, R. (1981). Teaching Swedish deaf preschool children to read. In P. S. Dale & D. Ingram (Eds.), Child language: An international perspective. Baltimore: University Park Press.

Sommers, R. K., & Taylor, M. L. (1972). Cerebral speech dominance in language-disordered and normal children. Cortex, 8, 224-232.

Sperling, G. (1960). The information available in brief visual presentations. Psychological Monographs, 74, No. 498.

Tomlinson-Keasey, C., & Kelly, R. R. (1978). The deaf child's symbolic world. American Annals of the Deaf, 123, 452-459.

Trybus, R. J., & Karchmer, M. A. (1977). School achievement scores of hearing-impaired children: National data on achievement status and growth patterns. American Annals of the Deaf, 122, 62-69.

Vernon, M. (1969). Sociological and psychological factors associated with hearing loss. Journal of Speech and Hearing Research, 12, 541-563.

Wallace, G., & Corballis, M. (1973). Short-term memory and coding strategies in the deaf. Journal of Experimental Psychology, 99, 334-348.

Witelson, S. F., & Rabinovitch, M. S. (1972). Hemispheric speech lateralization in children with auditory-linguistic deficits. Cortex, 8, 412-426.

Withrow, F. B. (1968). Immediate memory span of deaf and normally hearing children. Exceptional Children, 35, 33-41.

Wolff, V. G. (1973). Language, brain, and hearing: An introduction to the psychology of language with a section on deaf children's learning of language. London: Methuen & Co.

Wrightstone, J. W., Aranow, M. S., & Muskowitz, S. (1963). Developing test norms for the deaf child. American Annals of the Deaf, 108, 311-316.

Zaidel, E. (1976). Auditory vocabulary of the right hemisphere after brain bisection or hemidecortication. Cortex, 12, 191-211.

Zaidel, E. (1977). Unilateral auditory language comprehension on the Token Test following cerebral commissurotomy and hemispherectomy. Neuropsychologia, 15, 1-13.

Zeiser, M. L., & Erber, N. P. (1977). Auditory/Vibratory perception of syllabic structure in words by profoundly hearing-impaired children. Journal of Speech and Hearing Research, 20, 430-436.

Working Paper presented

at the

International Symposium

on

Cognition, Education, and Deafness

Gallaudet College, Washington, DC, June 5-8, 1984